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Book review

Review of An Interaction: Creativity, Cognition and Knowledge, Terry Dartnall (Ed.); Praeger, London, 2002, 337 pages

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In common parlance, creativity is understood as an extraordinary ability, with which only few are gifted. However, the book 'An Interaction: Creativity, Cognition and Knowledge' emphasizes the idea that creativity can be better understood as common cognitive phenomena. It poses a challenge to our understanding of the knowledge and performance of our cognitive systems. Drawing on the theoretical and methodological dynamism of psychology, computer science and artificial intelligence, this volume explores the current and potential advances in the psychological understanding of creativity, cognition and knowledge and their intricate connection with each other. The insights the book proposes are bound to have implications for the current status of cognitive science.

The book author holds that an account of creativity is the ultimate test for cognitive science. A system is said to be creative if it can articulate its domain-specific skills to itself as structures that it can reflect upon and change. Such an account will provide an explanation of how our creative products emerge, not out of combination of elements but out of our knowledge and ability. In the introduction, Dartnall vociferously argues that cognitive science is in need of a new epistemology that re-evaluates the role of representations in cognition, and accounts for the flexibility and fluidity of creative thought. He suggests that such an epistemology is already with us in some leading edge models of human creativity. This collection of papers by some of the leading figures in cognitive science is an endeavor in the same direction; they contribute scrupulously to Dartnall's project of redefining epistemology by their elaborate discussions on various aspects of creativity as mundane creativity, representational re-description, analogical thinking, fluidity and dynamic binding, input vs output creativity, emergent memory and emergence. Each chapter is followed by a lively debate with Dartnall about his call for a new epistemology, which steers a middle road between the representationism of classical cognitive science and a radical anti-representationism that denies the existence or importance of representations.

He argues that we construct representations in the imagination, rather than copy them from experience. It gives us the fluidity and flexibility that we need about creative cognition. Rather, cognition emerges out of our knowledge about a domain and our ability to express this knowledge as explicit, accessible thought. Hence, we need an epistemology which could account for the way in which we can understand the properties of the objects and vary them in the imagination. Such an epistemology recognizes the role of representations yet downplays the importance of it. He calls this epistemology, 'knowledge about' or 'property epistemology' because to know about something is to know its properties and to be able to vary them in the imagination. He argues that representations are constructed in our mind by the knowledge and the conceptual capabilities that we acquire in making sense of the world. We do this by redeploying capabilities that we first acquired in learning and problem solving.

In the first chapter, Douglas Hofstadter discusses David Cope's program, Emmy, which produces music that is hard to distinguish from that of the great masters. He says that Emmy's central mode of operation is based on breaking off and reassembling. In the local context, pieces must hook onto one another, and combine with each other in the way that they do in the input music. He calls this syntactic meshing, which concerns the content of the pieces, and is similar to the way in which we

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put jigsaw pieces together by looking at the picture we are building. However, he further says, the question remains as to how could Emmy produce deep and moving music. Even if she is not creative we need to know how can Emmy compose such wonderful stuff. He at length discusses the limits of combinationism.

Concurring with Dartnall's project, Prinz and Barsalou explore the contribution of perceptual symbols to the explanation of mundane creativity in concept acquisition. They have discussed concept acquisition as a form of creativity. The representations we form contribute to an ever growing repertoire of concepts. They develop an account of concept acquisition and explore prospects of constructing computational models of perceptual symbols using current strategies and technologies. They argue that a perceptual symbol system offers a more promising account: a class of non-arbitrary symbols like perceptual symbols is derived from the representations generated in perceptual input systems and therefore can be systematically combined and transformed. Perceptual symbols are multimodal and schematic.

Perceptual symbols can represent dynamic symbols which can be changed according to the context. When non-arbitrary symbols modify or accommodate each other in combination, new things can be discovered. For constructing perceptual system computationally, the authors prefer connectionist models because they are good at acquiring symbols, modeling perceptual input systems; they are context sensitive and address information semantically. But unlike classical models, connectionist models have difficulty achieving the kind of combinatorial behavior that we attributed to perceptual symbol systems. According to the authors, the major shortcoming of both the connectionist and the classical models is their lack of embodiment, which, they claim is the key to constructing a perceptual system. The constituents of perceptual symbol structures are generated through interaction with the world. They suggest that a model of perceptual symbol system must include mechanisms for grouping together multimodal symbols. Perceptual symbol systems yield multiple perceptual representations concurrently. Integration mechanisms converts these perceptual representations into symbols and groups them together to form concepts that can be assessed by higher level systems.

It can be said that constructing such an integration mechanism will be difficult. Prinz and Barsalou believe that perceptual symbols are structured or schematized and are inaccessible to consciousness. However, they have not given any evidence for their claim as to how representations are causally related to experiences. It will be difficult to outline a cognitive mechanism that enables us to freely recombine perceptual symbols to form representations of novel objects and events. We will thus also have a very large number of representations. Dogs come in so many different shapes and sizes that it is difficult to say how a single schematized representation covers all of them. Concept is a visual image, but difficult to see what kind of an image it could be. This cannot account for abstract cognition. Still they seem to be far away from the goal of constructing perceptual symbol systems that have all the features discussed above.

Donald M. Peterson discusses representational redescription and access. He holds that the phenomena of creativity can be understood as 'representation', that is, cases in which we increase our knowledge by refiguring knowledge which we already possess. This approach to knowledge gives an account the cognitive processes behind our thoughts and the recurring changes. It is an explication, that is, rearrangement or re-representation, which produces new output from old structures. Explication is creative where its access output at issue is new, but the knowledge or procedure accessed is not. When drawing procedures become accessible and manipulable, new drawings become possible, so that the performance can be altered in a flexible manner. In creative explication the cause is that a procedure or part of a cognitive system gains applicability or access to internal or external representations and the effect is an amplification of the system output. Thus, the effect is an emergent phenomenon; it has a cause but this is not for its own type (it does not itself constitute an item of system output). Hence, the result of explication may be new without its lacking antecedents, history and cause, the explication itself may without paradox be creative.

Following Dartnall, Peterson also argues that re-representation crucially involves the issue of access to knowledge, and the types of explication reveal several types of such access. He holds that our knowledge may be amplified through restructuring, as it may increase our ability to answer questions and solve problems. He identifies two broad types of explication. One, representational redescription is the explication of knowledge that is implicit in inner cognitive structures. Two, notational explication is the explication of knowledge that is implicit in external notations. Representational re-description hypothesis says that the mind is endogenously driven to go beyond what behavioral mystery and to re-describe and represent its knowledge to itself in increasingly abstract forms. It does this without any external pressure. In the course of development this knowledge is re-described as explicit, declarative knowledge that becomes available to other procedures, nor to the system as a whole. Peterson explains the levels of representation and outlines some of the experimental evidence.

Halford and Wilson believe that creativity requires explicit representations that are accessible to and modified by other cognitive processes without need of external processes. They say that the creativity requires the ability to represent and recursively modify explicit complex relations in parallel. In order to define this ability at a more theoretical level, they outline a hierarchy of six levels, and assess their effectiveness at mediating creativity. They claim that creativity depends partly on the ability to represent the relational structure of a task. They hold that relational representations have properties such as explicitness and accessibility to other cognitive processes, which enable them to be processed recursively. Therefore, representational re-description can be explained at least in part by the transition from associative to relational representations. Explicit, high level representation gives us dynamic binding, higher-order relations and the ability to change strategies.

Although the main model of these ranks proposed by Halford and Wilson is a connectionist one and they have taken up the challenge of giving a computational model, to some extent, but it would not be an easy task to access and explicate inner states of a connectionist model as they are explicitly symbolized. They have given a very rudimentary explanation for differences in creativity between animals and humans, between children and adults and between humans and machines.

John E. Hummel and Keith J. Holyoak understand creativity as mapping a problematic situation onto a structurally similar situation that we are more familiar with. Such analogies play an important role in creative thinking as it enables us to draw inferences in the sense of generating hypotheses. Analogical thinking has four major components: accessing a useful potential source analog, mapping the source to the target to identify systematic correspondences, using the mappings to draw new inferences about the target and inducing a generalized schema that captures the commonalities between the source and the target. Induction also depends on mechanisms that access and use relevant prior knowledge from outside the immediate of the problem at hand like reasoning by analogy. The central part of induction is the discovery of systematic correspondences among existing elements and using those correspondences to guide inference. The authors have developed a computational model of analogy based on very different assumptions of representations of analog elements and therefore the operations that discover the correspondences between them. They argue that LISA's (Learning and inference with schemas and analogies) present capabilities are a part of the complex phenomena of creativity. It fulfils some essential requirements for creativity. Structure mapping and schema induction involve the ability to appreciate abstract relational similarities between situations and the ability to induce a more general principle from those relational similarities. This they argue is the first step in creative thinking. They also talk about our ability to bootstrap ourselves beyond our limited inputs and processing capacity.

However, it can be argued that some analogical mappings do not have a structure. And the problem of how to derive the primitives of mental representation is a huge problem for LISA as well as for any model of higher cognitive function. All such models must assume a set of primitive features or symbols. However, all this work is preliminary. LISA also like other models is being limited to operating on a set of semantic primitives chosen largely by intuition.

Derek Partridge and Jon Rowe aim merely to shed some light on the relative merits of several computational mechanisms as accounts of the personal aspect of human creativity. They focus on two psychological theories of human creativity, the cortical arousal, or "special mechanism", theory and the theory that creativity does not involve a special mechanism, and that it is just normal problem solving. They implement them as minor variations of the same computational framework, based on Minsky's "Society of Mind" model of agents, or "k-lines". In this paradigm, low level, self-contained pieces of code called "agents" cooperate to construct representations. Their implementation, GENESIS, also features a representationally fluid emergent memory mechanism. They have presented a computational study of the nature and process of creativity. They distinguish between input and output creativity. Input creativity helps in solving problems and makes sense of the world while out put creativity when we deploy our knowledge to create something on our own. That is to say that the mechanisms and inner capabilities that are put into place during the input creativity phase are re-deployed in the output creativity phase.

Chris Thornton's paper adopts a strictly non-empirical approach to the study of creativity. Rather than offering a model of the experimental data, he aims at carrying out a logical analysis of the operational characteristics of basic learning procedures, and to use this analysis to tease out some interesting facts about the relationship between learning and some types of creativity. The key idea to be worked out is our ability to be creative might be partly founded on our ability to learn. He argues that certain creative processes may be viewed as learning processes running away out of control. He shows that the generative aspect of creativity may be understood in terms of a particular type of learning. The key observation developed is that the identification of a relationship within certain data effectively recodes those data. Author argues that relational learning always implicitly recodes the data, thus generates new data, and thus can potentially be applied recursively. He has not explained in what sense it is recursive. Paper just shows how the process of exploring conceptual spaces might be founded in some sort of runaway learning process.

In Chapter 8, Gary McGraw and Douglas Hofstadter discuss the Letter Spirit project and the chapter following it by John Rehling discusses the first full implementation of the project. It is difficult to quantify and model creativity. The letter spirit models the inherently creative task of type phase design. The project is an attempt to model central aspects of human high-level perception and creativity on a computer, focusing on the creative act of artistic letter-design. The aim is to model the process of rendering the 26 lowercase letters of the Roman alphabet in many different, internally coherent styles. Letter Spirit project is an attempt to model central aspects of human high-level perception and creativity on a computer. It is based on the belief that creativity is an automatic outcome of the existence of sufficiently flexible and context sensitive concepts or fluid concepts. The authors aim at implementing a model of fluid concepts in a challenging domain in order to get a clue to understand creativity. Not surprisingly, the project is a very complex undertaking and requires complex dynamic memory structures, as well as a sophisticated control structure based on the principles of emergent computation, in which complex high-level behavior emerges as a statistical consequence of many small computational actions.

In the final chapter in the book Richard Mc Donough suggests that emergentism offers the possibility of a kind of creativity that involves the birth of something genuinely new. That is to say more can come out of an organism than can be accounted for by what is materially/mechanically internal to the organism. Emergent materialism is the view that life and mind are emergent characteristics of matter. To put it in another way, a characteristic is said to be emergent if there is an explanatory gap between the properties of the base and the characteristic. In the end of the paper, Dartnall rightly points out as a criticism to his view that emergence is neither a necessary or sufficient condition for creativity.

Dartnall's approach suggests that current cognitive science needs to seek lessons from classical empiricism of Hume. He is not the first suggest an alternative epistemology by claiming it is our knowledge about the domain that does the hard cognitive work, and representations are constructed out of this knowledge; current research in cognitive science also supports the view that representations are not mere stored copies in the mind. However, his novel epistemological approach seems especially useful when it comes to accounting for complex cognition when creativity emerges where representations are not practically possible because they are not spatio-temporally present, like having an idea of a chiliagon (thousand-sided plane figure). Here one's creative imagination gets a boost by the extent to which one knows, i.e. a chiliagon is a thousand sided figure. This book presents a comprehensive survey of the current approaches to the study of creativity. Individual chapters contain discussions on various aspects of understanding cognition by the help of 'what we know'. The originality of the volume lies in the fact that it not only widely discusses the application aspect but also, at length deals with the problems one could envisage in one such project. The book has a lot of relevance for current research as it thoroughly examines the possibility of emergence of a new epistemology in terms of its computational implementations. The book provides a decisive and informative reply to attempts at redefining creativity in terms of knowledge. It offers an insightful and comprehensive account of a branch of cognitive psychology that is concerned with psychological and behavioral processes in naturalistic settings and that focuses on solving practical problems. The main contribution of the book is that its exhaustive coverage of useful techniques, areas of investigation, and findings of applied cognitive research, but it can be praised for its ability to offer each chapter as a tempting appetizer. More specifically, the authors present methodological and theoretical issues, and discuss the findings of numerous investigations in a rational (i.e., empirically based) and critical manner. The book will be of interest primarily to advanced students and researchers in the artificial intelligence, cognitive science, psychology and philosophy of mind, language.

Notwithstanding the vigorous efforts of Dartnall to cover most of the issues related to creativity, there is still much to be done in order to offer a complete working computational model of creativity. The book disappoints those working in more theoretical aspects of mind as it does not talk about issues as intentionality and its relations to creativity. The neuro-scientific aspect also needs more attention. Still because of its wide coverage of issues, the volume would be beneficial for libraries serving graduate programs in artificial intelligence, cognitive science, and the philosophy of mind.